PATENT ABSTRACTS OF JAPAN

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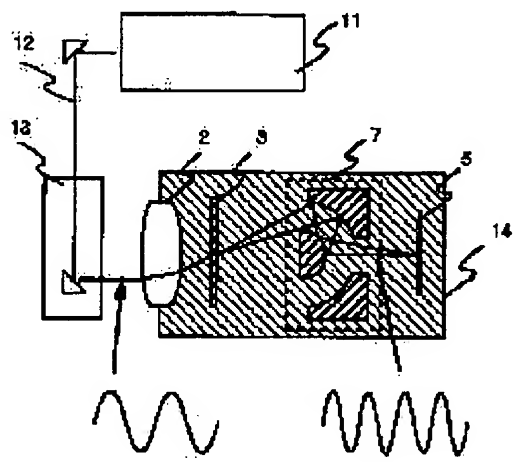
(71)Applicant : HITACHI LTD
(72)Inventor : FUKUDA HIROSHI
TANAKA TOSHIHIKO

(54) PATTERN FORMING METHOD AND EXPOSURE APPARATUS THEREFOR

(57)Abstract:
PURPOSE: To improve resolution by forming a projection optical system of an optical system having a reflection type lens, and fully filling entirety or part of an optical path of the projection system included between a surface of a board and the projection system with medium having 1 or more of specific refractive index to the air in the wavelength of a light.



CONSTITUTION: A beam 12 generated from a KrF excimer laser 11 is emitted to a mask 3 via a beam shaping optical system 13 and an illumination optical system 2. A light passing through the mask 3 is exposed on a board 5 via a reflection type contraction projection lens 7. The lens 7 is a Schwarzschild type optical system having a numerical aperture of 0.3 to focus the mask 3 on the board 5. The entire system from the irradiating side of the illumination system to the board via the mask is installed in a liquid vessel 14, and water is fully filled in the vessel to fill the water in the optical path. Then, a pattern is transferred to a positive resist film coating the Si board by using a projection exposure apparatus to form a 0.35μmL/S pattern.

CLAIMS

[Claim(s)]
[Claim 1 In a method of forming a pattern on the above-mentioned substrate by irradiating a mask with light which emitted a light source via an illumination-light study system, and carrying out image formation of the pattern on the above-mentioned mask to up to a substrate according to a projection optical system, A pattern formation method fulfilling the whole or a part of optical path of the above-mentioned projection optical system which constitutes the above-mentioned projection optical system according to an optical system containing a reflection type lens, and includes between the above-mentioned substrate and the above-mentioned projection optical systems at least by a medium with a bigger rate of specific refraction to air in wavelength of the above-mentioned light than 1.
[Claim 2 A pattern formation method whose above-mentioned medium is a fluid in claim 1.
[Claim 3 A pattern formation method whose wavelength of the above-mentioned light is 150-250 nm in claim 2.
[Claim 4 In an exposure device used when forming a pattern on the above-mentioned substrate by irradiating a mask with light which emitted a light source via an illumination-light study system, and carrying out image formation of the pattern on the above-mentioned mask to up to a substrate according to a projection optical system, A projection aligner fulfilling the whole or a part of optical path of the above-mentioned projection optical system which constitutes the above-mentioned projection optical system according to an optical system containing a reflection type lens, and includes between the above-mentioned substrate and the above-mentioned projection optical systems by a medium with a bigger rate of specific refraction to air in wavelength of the above-mentioned light than 1.
[Claim 5 A projection aligner which provides a transparent septum between the above-mentioned projection optical system and said substrate, and divides the above-mentioned medium into the optical system and substrate side in claim 4.

[Translation done.]

* NOTICES

DETAILED DESCRIPTION

[Detailed Description of the Invention
[0001]
[Industrial Application This invention relates to the pattern formation method for forming the minute pattern of various solid state components, and the projection aligner used for this.
[0002]
[Description of the Prior Art In order to improve the degree of location and working speeds of a solid state component, such as LSI, the minuteness making of the circuit pattern is progressing. The reduced-projection-exposure method excellent in mass production nature and resolution performance is widely used for the pattern formation of these now.
[0003]The optical system of a reduced-projection-exposure method is typically shown in drawing 2 (b). The light which emitted the effective light source 1 on a secondary surface of light source is irradiated by the mask 3 via the illumination-light study system 2, and image formation of the light diffracted with the pattern on the mask 3 is carried out on the substrate 5 with the reduction projection lens 4. What a reduction projection lens usually becomes from the combination of a refracted type lens is used. The resolution limit of this method was proportional to an exposure wavelength, and since it is in inverse proportion to the numerical aperture (NA) of a projection lens, improvement in a resolution limit has been performed by a raise in NA, and short wavelength formation. Conventionally, the circuit size became smaller than the wavelength of light after 64-megabit DRAM, and exposing light has reached the physical limit, although g line (wavelength of 436 nm) of a high-pressure mercury lamp and i line (wavelength of 365 nm) have been used.
[0004]The dipping (oil immersion) method is known as a method of on the other hand increasing effectual NA of the optical system of a microscope etc. By being filled up with the fluid (an oil is usually used) which has the bigger refractive index n than air between the tip of a lens, and a sample, this method sets wavelength of light to 1 n effectually, and raises

resolution. The application to the optical lithography of this method is discussed by the 53rd Japan Society of Applied Physics academic lecture meeting lecture proceedings, the 2nd paper search file, and the 472nd page (1992), for example.

[0005]On the other hand, the method of using reflection type projection optical systems, such as a step and scanning method, is examined as another gestalt of the projection aligner for optical lithographies. This optical system is not based on wavelength, but realization of it is enabled to NA with a maximum of 0.7 big grade, and it is dramatically promising as a future exposure device. In this method, since the chromatic aberration correction of what uses a refraction type optical element in part is possible, it exposes in a wavelength area comparatively as large as 245-253 nm of a xenon mercury lamp, for example. For this reason, narrow-band-izing of a precise laser wavelength spectrum like an excimer laser stepper and the stabilization of absolute wavelengths using the conventional full refraction type optical system are not needed, and the multiple interference effect and a standing wave effect can be reduced. It is the practical big feature that an exposure area is also large.

[0006]The optical system of the step and scanning method is discussed by the 14th page from the 12th page of resist material process technology (TECHNICAL INFORMATION INSTITUTE, Tokyo, 1991), for example.

[0007]

[Problem(s) to be Solved by the Invention By the way, between a lens tip and a sample, refraction type objective lenses, such as a microscope used with the above-mentioned conventional immersion method, are designed for exclusive use on the assumption that it is filled up with the fluid of a predetermined refractive index. The same of this situation may be said of the case of the lens for projection exposure, and it is necessary to design the projection lens corresponding to dipping specially as an exclusive lens with a design which is completely conventionally different from a lens. Here, suppose that the fluid restoration field 6 (drawing 2 (b) shadow area) between the tip of conventional-type dioptric lenses other than for dipping and a substrate (or sample) was temporarily filled up with the fluid of the refractive index n. In this case, although wavelength is effectually set to 1 n, since the angle of refraction in a lens tip decreases according to a Snell's law, the optical path of a beam of light changes like the dashed line of drawing 2 (b), and effectual NA decreases. For this reason, resolution does not necessarily improve. And there was a problem that it was very difficult to reconcile with big NA peculiar to an immersion lens the large exposure area demanded in the lens for steppers.

[0008]On the other hand, it is preferred to shorten an exposure wavelength as much as possible, in order to improve the resolution of optical lithography further. However, both the exposing method by a conventional-type dioptric system and the reflection type projection exposure method had the problem that an ArF excimer laser (wavelength of 193 nm) will be a limit of practical short wavelength formation from the limit of the transmissivity of an optical

material.

[0009]There is in providing the pattern formation method which can be improved to a limit in the resolution of a projection exposure method, the purpose of this invention acquiring a resolution improved effect equivalent to having carried out short wavelength formation effectually simple, and securing a large exposure region, without changing greatly the composition and the optical system of an exposure device of a conventional type.

[0010]

[Means for Solving the Problem In a method of forming a pattern on the above-mentioned substrate by this invention's irradiating a mask with light which emitted a light source via an illumination-light study system, and carrying out image formation of the pattern on the above-mentioned mask to up to a substrate according to a projection optical system, in order to attain the above-mentioned purpose, An optical system containing a reflection type lens constitutes the above-mentioned projection optical system, and the whole or a part of optical path of the above-mentioned projection optical system which includes between the above-mentioned substrate and the above-mentioned projection optical systems at least is fulfilled by a medium with a bigger rate of specific refraction to air in wavelength of the above-mentioned light than 1.

[0011]

[Function]It considers changing the refractive index of the medium which fulfills the whole optical path of the catoptric system shown in drawing 2 (a). Drawing 2 (a) transposes the refracted type reduction projection lens 4 in drawing 2 (b) to the reflection type reduction projection lens 7. In drawing 2 (a), the solid line and the dotted line showed respectively the optical path of a beam of light when the refractive index of a medium is small, and the optical path of the beam of light in the case of being large. The optical path in a catoptric system is decided only by the shape of surface type of a reflecting lens according to the law of reflection, and is not based on the refractive index of a medium. Therefore, even if it changes the refractive index of a medium, the geometric optics character of optical systems, such as a numerical aperture, does not change at all. On the other hand, if the substance of the rate n of specific refraction to a vacuum is used as a medium, wavelength will be effectually set to 1 n. As a result, an effect equal to only wavelength having become short substantially is acquired. in addition -- although the perfect catoptric system was assumed and explained by drawing 2 (a) since it was easy -- partial -- a dioptric system -- business -- a potato is good.

[0012]A medium is 1.2, in order that it may be desirable for the refractive index to an exposure wavelength to be large as much as possible and it may acquire sufficient resolution effect. It is desirable that it is above. It is substantially transparent to an exposure wavelength, and it is desirable not to have an adverse effect on an optical element and resist. Specifically, the fluid which dissolved organic solvents, such as water or alcohol, and straight chain hydrocarbon,

silicone resin and also the inorganic compound, or the organic compound in these, the various liquids currently conventionally used in an immersion microscope, the dipping method of determination of index of refraction, etc., etc. can be used, for example.
[0013]As for these temperature, since there is a possibility of having an adverse effect on the imaging characteristic of an optical system when a refractive index changes with fluctuation of the temperature of a medium, density, etc. in an optical system, controlling carefully is desirable. Since a substrate is especially scanned to an optical system by a scanning optical system, it is preferred to take care so that an imaging characteristic may not change with the flows of a medium.
[0014]
[Example
(Example 1) The reflection type projection aligner by one example of this invention is shown in drawing 1. The mask 3 is irradiated with the laser beam 12 generated from KrF excimer laser 11 via the beam shaping optical system 13 and the illumination-light study system 2. The light which passed the mask exposes the substrate 5 via the reflection type reduction projection lens 7. Reflection type reducing glass carries out image formation of the mask 3 on the substrate 5 by the Schwartz SHURUDO type optical system of the numerical aperture 0.3. However, the optical system in a figure is typical strictly, and is not what showed the composition of the actual optical system faithfully. Here, the whole optical system from the ejection side of an illumination-light study system to a substrate through a mask was installed in the inside of the liquid container 14, water was filled and the liquid container was filled up with the optical path with water.
[0015]Next, it is 0.35micromL S as a result of transferring the pattern of various sizes using a projection aligner on the positive-resist film (PMMA, 1 micrometer of thickness) applied on the Si substrate. The pattern has been formed. For comparison, when water was removed from the optical system and having been exposed in the air, the resolution limit retreated to 0.5 micrometer.
[0016]The wavelength of an exposure device, the kind of light source, the method of a projection lens and a numerical aperture, the kind of medium, the resist process to be used, a mask pattern size, etc. are not limited to what was shown in this example. For example, a high-pressure mercury lamp and a xenon mercury lamp may be used instead of excimer laser. Into a fluid solution, it may replace with water and perfluoroalkyl polyether etc. may be used. While this fluid was transparent to the exposure wavelength, the sensitization characteristic of resist was not affected at all. It may replace with PMMA also as resist and a suitable novolac system positive resist, chemical amplification system resist, etc. may be used.
[0017](Example 2) The reflection type projection aligner by the second example of this invention is shown in drawing 3. The mask 3 is irradiated with the laser beam generated from

the ArF excimer laser (not shown) via a beam shaping optical system and an illumination-light study system (not shown). The light which passed the mask exposes the substrate 5 via the scanning catoptric system 21. A scanning catoptric system is a step and scan type optical system of the numerical aperture 0.7, and carries out image formation of the mask 3 on the substrate 5. However, the optical system in a figure is typical strictly, and is not what showed the composition of the actual optical system faithfully. Here, the field 22 shown with the slash in a figure within the optical path of a projection optical system was filled up with water.
[0018]Next, it is 0.11micromL S as a result of transferring the pattern of various sizes using a projection aligner on the positive-resist film (PMMA, 1 micrometer of thickness) applied on the Si substrate. The pattern has been formed. A resolution limit is 0.15 micrometer, when water was removed from the optical system and it exposed in the air for comparison. It retreated and the effect of this invention was checked.
[0019](Example 3) In the projection aligner of Example 2, as shown in drawing 4, the parallel plate 31 of quartz divided the optical system and substrate side. In order that the flow of the liquid medium produced when a substrate is scanned to an optical system or step feed is carried out by this might not attain to the optical system side, the influence of fluctuation etc. of the refractive index was suppressed and the dimensional accuracy of the pattern improved. To the spherical aberration generated by quartz window insertion, it amended beforehand.
[0020](Example 4) In the projection aligner of Example 2, as shown in drawing 5, the quartz parallel plates 32 and 33 were formed between the optical system and the substrate, and the liquid container was divided into the optical system side liquid container 34 and the substrate side liquid container 35. It was made to perform the scan or step feed to the optical system of the substrate 5 the whole substrate side liquid container 35. Thereby, since the liquid flow near the substrate was also controlled, the influence of fluctuation etc. of the refractive index was suppressed and the dimensional accuracy of the pattern improved further.
[0021]When applying the composition by this example to Example 1, the same mechanism also as the mask side can be formed.
[0022]
[Effect of the Invention In this invention, image formation of the mask pattern is carried out to up to a substrate according to a projection optical system.
Therefore, when transferring a pattern on the above-mentioned substrate, while the optical system containing a reflection type lens constitutes a projection optical system, By fulfilling the whole or a part of optical path of a projection optical system including between a substrate face and projection optical systems by a medium with a bigger rate of specific refraction to the air in the wavelength of light than 1, Improvement in resolution equivalent to having carried out short wavelength formation effectually simple can be aimed at without changing greatly the composition and the optical system of an exposure device of a conventional type.

Thereby, the resolution limit of optical lithography is improved about 30 , and it is 0.15 micrometer. It becomes possible to form the following patterns.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings
[Drawing 1 The explanatory view of the principle of this invention.
[Drawing 2 The explanatory view of the exposure device by one example of this invention.
[Drawing 3 The explanatory view of the exposure device by the second example of this invention.
[Drawing 4 The explanatory view of the exposure device by the third example of this invention.
[Drawing 5 The explanatory view of the exposure device by the fourth example of this invention.
[Description of Notations
2 [-- A reflection type reduction projection lens, 11 -- Excimer laser, 12 -- A laser beam, 13 / -- A beam shaping optical system, 14 / -- Liquid container. -- An illumination-light study system, 3 -- A mask, 5 -- A substrate, 7

[Translation done.]

* NOTICES

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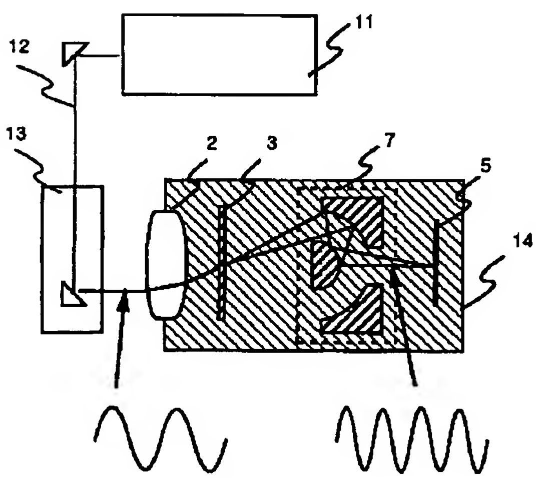
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

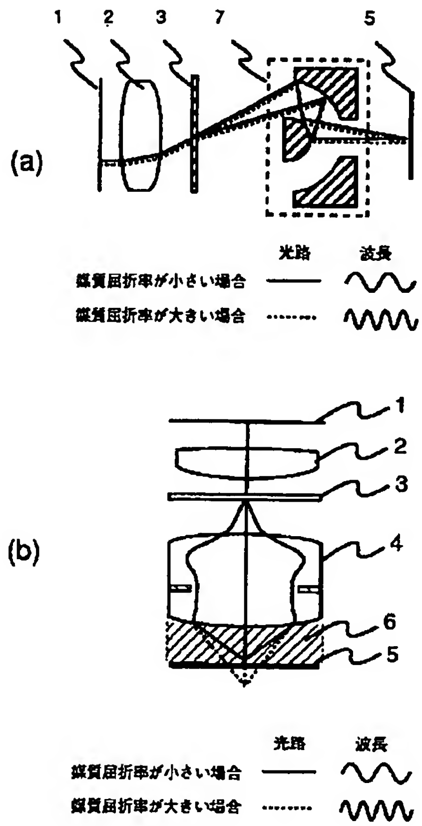
[Drawing 1

図1



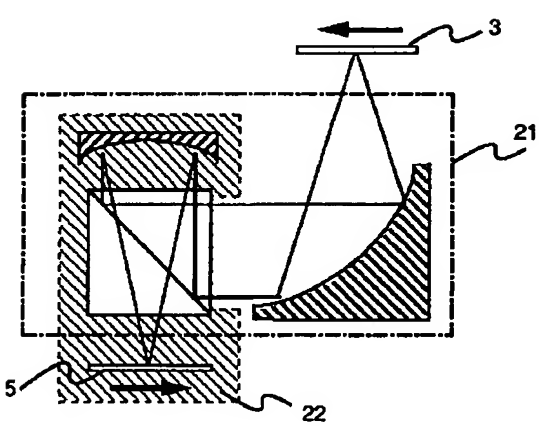
[Drawing 2

図2



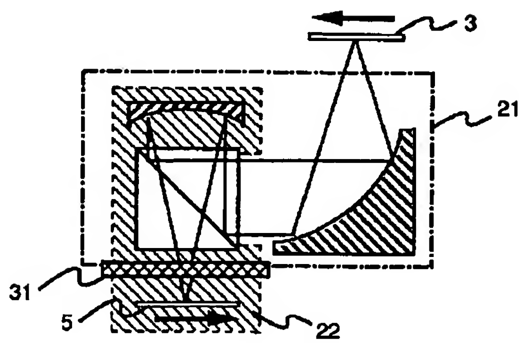
[Drawing 3

図3



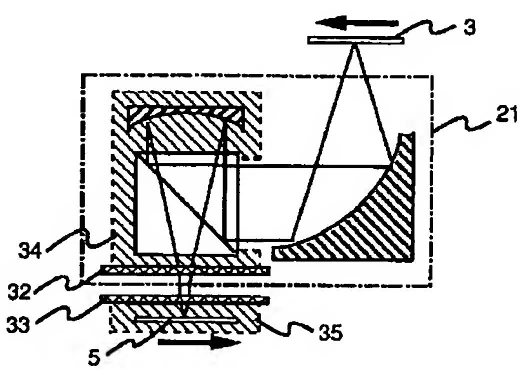
[Drawing 4

図4



[Drawing 5

図5



[Translation done.]

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(71)出願人　000005108
株式会社日立製作所
東京都千代田区神田駿河台四丁目6番地

(72)発明者　福田　宏
東京都国分寺市東恋ケ窪1丁目280番地
株式会社日立製作所中央研究所内

(72)発明者　田中　稔彦
東京都国分寺市東恋ケ窪1丁目280番地
株式会社日立製作所中央研究所内

(74)代理人　弁理士　小川　勝男

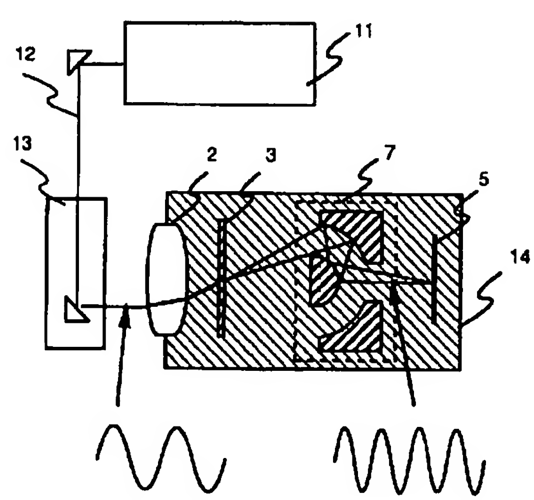
(54)【発明の名称】　パターン形成方法及びその露光装置

(57)【要約】

【構成】マスクパターン3を反射型レンズ7により基板5上へ結像させ、基板5の表面と反射型レンズ7の間を含む露光光学系の光路の全体又は一部を、露光波長における屈折率が1より大きな液体で満たす。

【効果】簡便に実効的に短波長化したのと同等の解像力向上効果を得ることができ、光リソグラフィの解像限界を30％程度向上し、0.15μm 以下のパターンを形成することができる。

図1



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【特許請求の範囲】

【請求項1】光源を発した光を照明光学系を介してマスクに照射し、上記マスク上のパターンを投影光学系により基板上へ結像させることにより上記基板上にパターンを形成する方法において、上記投影光学系を反射型レンズを含む光学系により構成し、少なくとも上記基板と上記投影光学系の間を含む上記投影光学系の光路の全体又は一部を、上記光の波長における空気に対する比屈折率が1より大きな媒質で満たすことを特徴とするパターン形成方法。

【請求項2】請求項1において、上記媒質は液体であるパターン形成方法。

【請求項3】請求項2において、上記光の波長は150～250nmであるパターン形成方法。

【請求項4】光源を発した光を照明光学系を介してマスクに照射し、上記マスク上のパターンを投影光学系により基板上へ結像させることにより上記基板上にパターンを形成する際に用いられる露光装置において、上記投影光学系を反射型レンズを含む光学系により構成し、上記基板と上記投影光学系の間を含む上記投影光学系の光路の全体又は一部を、上記光の波長における空気に対する比屈折率が1より大きな媒質で満たしたことを特徴とする投影露光装置。

【請求項5】請求項4において、上記投影光学系と前記基板の間に、透明な隔壁を設け、上記媒質を光学系側と基板側に分割する投影露光装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、各種固体素子の微細パターンを形成するためのパターン形成方法、及びこれに用いられる投影露光装置に関する。

【0002】

【従来の技術】LSI等の固体素子の集積度及び動作速度を向上するため、回路パターンの微細化が進んでいる。現在これらのパターン形成には、量産性と解像性能に優れた縮小投影露光法が広く用いられている。

【0003】図2（b）に縮小投影露光法の光学系を模式的に示す。二次光源面上の有効光源1を発した光は照明光学系2を介してマスク3に照射され、マスク3上のパターンにより回折された光は縮小投影レンズ4により基板5上へ結像される。縮小投影レンズは通常屈折型レンズの組合せからなるものが用いられる。この方法の解像限界は露光波長に比例し、投影レンズの開口数（NA）に反比例するため、高NA化と短波長化により解像限界の向上が行われてきた。従来、露光光は、高圧水銀ランプのg線（波長436nm），i線（波長365nm）が用いられてきたが，64メガビットDRAM以降回路寸法が光の波長より小さくなり、物理的限界に達している。

【0004】一方、顕微鏡等の光学系の実効的なNAを

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増大させる方法として、液浸（油浸）法が知られている。この方法は、レンズの先端と試料の間に空気より大きな屈折率nを有する液体（通常油を用いる）を充填することにより、実効的に光の波長を1／nとして解像度を向上させる。この方法の、光リソグラフィへの応用は、例えば、第53回応用物理学会学術講演会講演予稿集，第2分冊，第472頁（1992年）に論じられている。

【0005】一方、光リソグラフィ用の投影露光装置の別の形態として、ステップアンドスキャン方式等の反射型投影光学系を用いる方法が検討されている。この光学系は波長によらず最大0.7程度の大きなNAまで実現可能とされ、将来の露光装置として非常に有望である。この方式では、一部に屈折型光学素子を使用するものの色収差補正が可能なため、例えば、キセノン水銀ランプの245～253nmという比較的広い波長領域で露光を行う。このため、従来の完全屈折型光学系を用いるエキシマレーザステッパの様な精密なレーザ波長スペクトルの狭帯域化と絶対波長の安定化を必要とせず、又、多重干渉効果と定在波効果を低減することができる。又、露光面積が広いことも実用上の大きな特長となっている。

【0006】ステップアンドスキャン方式の光学系は、例えば、レジスト材料プロセス技術（技術情報協会，東京，1991年）第12頁から第14頁に論じられている。

【0007】

【発明が解決しようとする課題】ところで、上記の従来液浸法で用いられる顕微鏡等の屈折型対物レンズは、レンズ先端と試料の間に所定の屈折率の液体を充填することを前提として専用に設計されたものである。この事情は投影露光用レンズの場合も同様であり、液浸対応の投影レンズは従来レンズとは全く異なる設計をもつ専用レンズとして特別に設計する必要がある。ここで、仮に液浸用以外の従来型屈折レンズの先端と基板（又は試料）の間の液体充填領域6（図2（b）斜線部分）に屈折率nの液体を充填したとする。この場合、波長は実効的に1／nになるが、スネルの法則に従いレンズ先端における屈折角が減少するため、光線の光路は図2（b）の破線の様に変化して実効的なNAが減少する。このため、必ずしも解像度は向上しない。しかも、ステッパ用レンズにおいて要求される広い露光面積を，液浸レンズ特有の大きなNAと両立させるのは極めて困難であるという問題があった。

【0008】一方、光リソグラフィの解像度をさらに向上するには、露光波長をできるだけ短くすることが好ましい。しかし、従来型屈折光学系による露光法，反射型投影露光法のいずれも、光学材料の透過率の限界からArFエキシマレーザ（波長193nm）が実用的な短波長化の限界となってしまうという問題があった。

【0009】本発明の目的は、従来型の露光装置の構成

と光学系を大きく変更することなく、簡便に実効的に短波長化したのと同等の解像力向上効果を得て、広い露光領域を確保しつつ投影露光法の解像度を極限まで向上することが可能なパターン形成方法を提供することにある。

【0010】

【課題を解決するための手段】上記目的を達成するため、本発明は、光源を発した光を照明光学系を介してマスクに照射し、上記マスク上のパターンを投影光学系により基板上へ結像させることにより上記基板上にパターンを形成する方法において、上記投影光学系を反射型レンズを含む光学系により構成し、少なくとも上記基板と上記投影光学系の間を含む上記投影光学系の光路の全体又は一部を、上記光の波長における空気に対する比屈折率が1より大きな媒質で満たす。

【0011】

【作用】図2（a）に示す反射光学系の光路全体を満たす媒質の屈折率を変化させることを考える。図2（a）は、図2（b）における屈折型縮小投影レンズ4を反射型縮小投影レンズ7に置き換えたものである。図2（a）において、媒質の屈折率が小さい場合の光線の光路と大きい場合の光線の光路を各々実線と点線で示した。反射光学系中の光路は、反射の法則に従い反射レンズの表面形状のみによって決まり、媒質の屈折率によらない。従って、媒質の屈折率を変化させても、開口数等の光学系の幾何光学的な性質は何ら変化しない。一方、媒質として真空に対する比屈折率ｎの物質を用いると、波長は実効的に１／ｎとなる。この結果、実質的に波長だけが短くなったのと等しい効果が得られる。なお、図2（a）では簡単のため完全な反射光学系を仮定して説明したが、部分的には屈折光学系を用いもよい。

【0012】また媒質は、露光波長に対する屈折率ができるだけ大きいことが望ましく、十分な解像度効果を得るために、1.2 以上であることが望ましい。又、露光波長に対して実質的に透明で、かつ、光学素子及びレジストに悪影響を与えないことが望ましい。具体的には、例えば、水、又はアルコール，直鎖炭化水素等の有機溶媒，シリコーン樹脂、更に無機化合物又は有機化合物をこれらに溶解した液体、又、従来液浸顕微鏡や液浸屈折率測定法等において使用されている各種液体等を用いることができる。

【0013】なお、光学系中で媒質の温度や密度等のゆらぎにより屈折率が変化すると、光学系の結像特性に悪影響を及ぼす恐れがあるため、これら温度等は注意深く制御することが望ましい。特に、走査光学系では光学系に対して基板を走査するので、媒質の流れにより結像特性が変化しないように気を付けることが好ましい。

【0014】

【実施例】

（実施例1）本発明の一実施例による反射型投影露光装置を図1に示す。ＫｒＦエキシマレーザ１１から発生したレーザ光１２を、ビーム整形光学系１３及び照明光学系２を介してマスク３に照射する。マスクを通過した光は反射型縮小投影レンズ７を介して基板５を露光する。反射型縮小レンズは開口数０.３ のシュバルツシュルド型光学系で、マスク３を基板５上に結像させる。但し、図中の光学系はあくまで模式的なものであり、実際の光学系の構成を忠実に示したものではない。ここで、照明光学系の射出側からマスクを経て基板に至る光学系の全体を液体容器１４の内部に設置し、液体容器中に水を満たして光路を水で充填した。

【0015】次に、投影露光装置を用いて、Ｓｉ基板上に塗布したポジ型レジスト膜(PMMA,膜厚１μｍ）に様々な寸法のパターンを転写した結果、０.３５μｍL／Ｓパターンを形成できた。比較のため、光学系から水を除去し空気中で露光を行ったところ解像限界は０.５μｍに後退した。

【0016】なお、露光装置の波長，光源の種類，投影レンズの方式及び開口数，媒体の種類，使用するレジストプロセス，マスクパタン寸法等、本実施例に示したものに限定しない。例えば、エキシマレーザの代わりに、高圧水銀ランプやキセノン水銀ランプを用いてもよい。又、液体溶液中に水に代えて、パーフルオロアルキルポリエーテル等を用いてもよい。この液体は、露光波長に透明であるとともにレジストの感光特性に全く影響を与えなかった。又、レジストとしても、ＰＭＭＡに代えて適当なノボラック系ポジ型レジストや化学増幅系レジスト等を用いてもよい。

【0017】（実施例2）本発明の第二の実施例による反射型投影露光装置を図3に示す。ＡｒＦエキシマレーザ（図示せず）から発生したレーザ光を、ビーム整形光学系及び照明光学系（図示せず）を介してマスク３に照射する。マスクを通過した光は走査型反射光学系２１を介して基板５を露光する。走査型反射光学系は開口数０.７ のステップアンドスキャン型光学系で、マスク３を基板５上に結像させる。但し、図中の光学系はあくまで模式的なものであり、実際の光学系の構成を忠実に示したものではない。ここで、投影光学系の光路内の図中斜線で示した領域２２に水を充填した。

【0018】次に、投影露光装置を用いて、Ｓｉ基板上に塗布したポジ型レジスト膜(PMMA,膜厚１μｍ）に、様々な寸法のパターンを転写した結果、０.１１μｍL／Ｓ パターンを形成できた。比較のため、光学系から水を除去し空気中で露光を行ったところ、解像限界は０.１５μｍ に後退し、本発明の効果が確認された。

【0019】（実施例3）実施例2の投影露光装置において、図4に示す様に光学系側と基板側とを石英の平行平板３１により分割した。これにより、基板を光学系に対して走査したりステップ送りしたときに生じる液体媒質の流れが光学系側に及ぶことがないため、屈折率の揺

らぎ等の影響が抑えられてパターンの寸法精度が向上した。なお、石英窓挿入により発生する球面収差に対しては、あらかじめ補正を行った。

【0020】（実施例4）実施例2の投影露光装置において、図5に示す様に光学系と基板の間に石英平行平板32，33を設け、液体容器を光学系側液体容器34と基板側液体容器35に分割した。更に基板5の光学系に対する走査又はステップ送りを、基板側液体容器35ごと行うようにした。これにより、基板近傍での液体の流れも抑制することができるため、屈折率の揺らぎ等の影響が抑えられてパターンの寸法精度が更に向上した。

【0021】なお、本実施例による構成を実施例1に適用する場合、マスク側にも同様の機構を設けることができる。

【0022】

【発明の効果】本発明によれば、マスクパターンを投影光学系により基板上へ結像させることにより上記基板上にパターンを転写する際、投影光学系を反射型レンズを含む光学系により構成するとともに、基板表面と投影光学系の間を含む投影光学系の光路の全体又は一部を、光の波長における空気に対する比屈折率が1より大きな媒質で満たすことにより、従来型の露光装置の構成と光学系を大きく変更することなく、簡便に実効的に短波長化したのと同等の解像力向上を図ることができる。これにより、光リソグラフィの解像限界を30％程度向上し、0.15μm 以下のパターンを形成することが可能となる。

【図面の簡単な説明】

【図1】本発明の原理の説明図。

【図2】本発明の一実施例による露光装置の説明図。

【図3】本発明の第二の実施例による露光装置の説明図。

【図4】本発明の第三の実施例による露光装置の説明図。

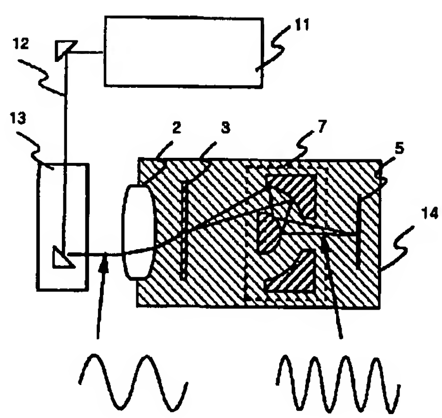
【図5】本発明の第四の実施例による露光装置の説明図。

【符号の説明】

2…照明光学系、3…マスク、5…基板、7…反射型縮小投影レンズ、11…エキシマレーザ、12…レーザ光、13…ビーム整形光学系、14…液体容器。

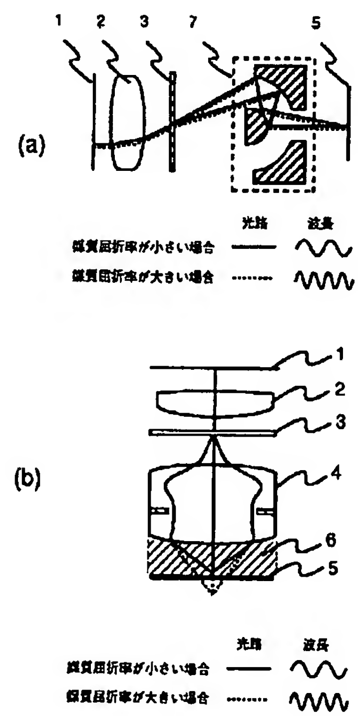
【図1】

図1



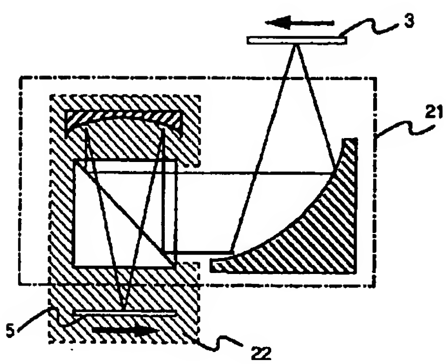
【図2】

図2



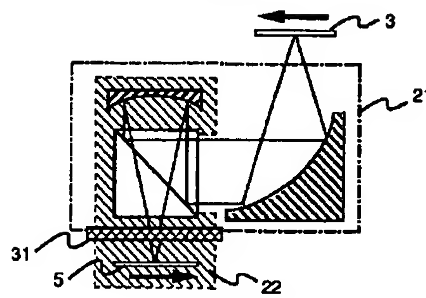
【図3】

図3



【図4】

図4



【図5】

図5